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AUTHOR Sharma, Priya; Hannafin, Michael J.

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ABSTRACT

Recently, attention has focused on developing methods for facilitating critical thinking in students. Scaffolding is a method that has been successfully used in many settings to support different learning goals. This study focused on the influence of scaffolding on critical thinking skills in a technology-mediated environment. The main research questions explored changes in participant use of scaffolding and influences on the evolution of critical thinking. A qualitative design guided data collection and analysis. Five graduate participants were purposefully selected from an online instructional design class and interviewed repeatedly over one semester. Major findings indicated that participant use of scaffolding moved from externally directed to internally relevant assimilation. Influences on the evolution of critical thinking included prior knowledge, reflection, feedback, project context, and perception of self as learner. Implications for research and practice are outlined. (Contains 40 references.) (Author)

The Evolution of Critical Thinking and Use of Scaffolding in a Technology-Mediated Environment

Priya Sharma
Instructional Systems, The Pennsylvania State University
United States
psharma@psu.edu

Michael J. Hannafin
The Learning and Performance Support Laboratory
The University of Georgia
United States
Hannafin@coe.uga.edu

Abstract Recently, attention has focused on developing methods for facilitating critical thinking in students. Scaffolding is a method that has been successfully used in many settings to support different learning goals. This study focused on the influence of scaffolding on critical thinking skills in a technology-mediated environment. The main research questions explored changes in participant use of scaffolding and influences on the evolution of critical thinking. A qualitative design guided data collection and analysis. Five graduate participants were purposefully selected from an online instructional design class and interviewed repeatedly over one semester. Major findings indicated that participant use of scaffolding moved from externally directed to internally relevant assimilation. Influences on the evolution of critical thinking included prior knowledge, reflection, feedback, project context, and perception of self as learner. Implications for research and practice are outlined.

Introduction

This paper describes a study conducted to explore the influence of scaffolding on critical thinking skills in a technology-mediated environment. With the recent increase in online education and Internet-based content, the development of critical thinking skills becomes more important, along with the development of methods for supporting critical thinking. Much attention has been focused on identifying and developing methods for supporting and facilitating learning in non-traditional environments. Scaffolding is one method that has been used in a variety of settings, ranging from one-on-one tutoring to traditional classrooms for supporting very different learning goals (Bliss, Askew, & Macrae, 1996; Graves & et al., 1996; Hogan & Pressley, 1997; Lepper, Drake, & O'Donnell-Johnson, 1997; Palincsar, 1986; Saxe, Gearhart, & Guberman, 1984; Wood, Bruner, & Ross, 1976).

Scaffolding was first defined as a process by which an expert supports a learner in the accomplishment of a task beyond the learner's individual capabilities, and then gradually fades that support as the learner becomes more competent in task accomplishment (Wood et al., 1976). Scaffolding has been used effectively in classroom environments for supporting the learning of reading (Palincsar, 1986), language (Roehler & Cantlon, 1997), mathematics (Schoenfeld, 1991), and scientific inquiry (Hogan & Pressley, 1997). In these environments, teachers interact with groups of students, providing them with appropriate support through modeling, questioning, or cued reflection and externalization of metacognition. Studies have shown that through such support and scaffolding, students gradually internalize cognitive processes and assume responsibility for and control of their own learning (Roehler & Cantlon, 1997).

Researchers have tried to broaden the availability and application of scaffolding by developing technology-mediated and technology-based scaffolding. Despite the limitations of computer-based intelligent systems in emulating the sensitivity and responsiveness of the human expert, computers were able to mediate and emulate certain facets of the scaffolding process (Chee, 1995; Guzdial, 1994; Kao & et al., 1996; Soloway et al., 1993). In most cases, these applications functioned as on-demand help systems and provided the learner with procedural and directive instructions for task completion.

Recently, a few technology-based scaffolding applications have been developed that address the internalization of cognitive strategies and higher order thinking skills. *Reading Partner* (Salomon, Globerson, & Guterman, 1989) focused on supporting the internalization of metacognitive strategies by providing intellectual and pedagogical scaffolding for seventh graders' reading skills. Despite the lack of fading, the continuous introduction of metacognitive questions and hints resulted in students' internalization of strategies and improvements in a near transfer task—writing.

The *Web-based Inquiry Science Environment* (WISE) (University of California at Berkeley, 1999), another prominent application, focused on scaffolding students' scientific inquiry and higher order thinking skills on the Internet. With the help of the software tools and scaffolding in the form of questions, students evaluated web sites and asked critical questions aimed at evaluating the utility of the site's content for a specific project. Empirical evidence indicated that scaffolding tools positively influenced students' critiques and their ability to ask critical questions (Slotta & Linn, 2000).

Research indicates that scaffolding of higher order thinking skills is best achieved through metacognitive hints and questions—directive guidance seems to engender an over-dependence on scaffolding and reduces the capability of the learner to function independently (see for example, Kao & Lehman, 1997). Additionally, scaffolding must be overtly faded to encourage and identify the transfer of metacognitive strategies to related future tasks. Apart from techniques and implementations of scaffolding, internalization of cognitive strategies is also affected by context and task structure. Research indicates that students' ability to assimilate technology-based scaffolding is increased by providing goals and orientation (Oliver & Hannafin, 2000; Slotta & Linn, 2000).

Students' epistemological readiness and interests mediate both the use of scaffolding (Oliver & Hannafin, 2000; Sherman, 1994) and the ability to think reflectively and critically (King & Kitchener, 1994; Kuhn, 1999). For younger students, directive and instructive scaffolding may prove more effective because of students' naïve epistemologies and willingness to accept authoritative knowledge (Kuhn, 1999). For slightly older students, however, scaffolding in the form of Socratic and open-ended questions might prove more effective due to students' epistemological readiness to question and seek knowledge.

Research Questions and Design

Based on reviewed literature and studies and the purpose of the current study, three major research questions were addressed:

- How does student perception and use of scaffolding evolve?
- What processes and sources influence the development of critical thinking skills?

A qualitative research design was used to meet the purpose of the study and to address the research questions. The study was conducted in the context of a primarily online Instructional Design (ID) offered in the spring semester 2001 in a large Southeastern university. Within this online environment, scaffolding supported the performance of critical thinking tasks in ID. Data were mainly gathered by interviewing five purposefully selected graduate students within the course. Participants were selected through administration of the Cornell Critical Thinking Test (CCTT) Level Z test (Fisher & Scriven, 1997) and their willingness and ability to articulate their thinking and learning. Participant generated documents were used to cue recall during the interviews. Interview data were analyzed using the constant comparison method (Glaser & Strauss, 1967).

During the course, the students used a textbook as a primary source of content and instruction. In addition, systematic, deliberate, and static scaffolding was provided via course materials at five discrete intervals to coincide with the completion of specific class-based tasks. The scaffolding, designed collaboratively by the researcher and course instructor, was designed to facilitate deeper reflection, metacognition, and critical thinking for the execution of six class-related documents. Decisions about level and type of scaffolding were negotiated throughout the course, and scaffolding was gradually faded.

Students accessed the static scaffolding directly through the web page that described the assignment. Thus, the task was presented concurrently with the appropriate mode of scaffolding—Socratic questioning, modeling, or externalization of metacognition and reflection. The scaffolding provided for critical thinking in relation to Instructional Design was based on relevant literature in ID (Briggs, 1977; Dick & Carey, 1985; Smith & Ragan, 1993), critical thinking (Beyer, 1997; Ennis, 1987; Paul, 1990), and scaffolding (Hogan & Pressley, 1997; Rogoff & Wertsch, 1984; Vygotsky, 1978; Wertsch, 1984; Wood & Wood, 1996).

Data were gathered through two main sources: interviews and participant document artifacts, which included six assignments that were directly related to participants' individual instructional projects, and four concept maps generated at various stages by each participant. Participants were interviewed five times during the semester, at an interval of 2-3 weeks and during interviews, the concept maps and document assignments were used as visual triggers for participants to reflect on their meaning making process. Some participants also generated bi-weekly journals that detailed their thinking and experiences in ID. Also, participants posted their reflections about changes in their individual views of ID on the class bulletin board at the middle and end of the semester. Transcripts of the reflective bulletin board activities were used as additional document data, in conjunction with the reflective journals generated by some participants. The multiple sources of data also provided a source of triangulation and validity.

Major Findings

Use of Scaffolding

Initially, some participants perceived the scaffolding as directive and used the questions and examples as directions for task completion. For example, one participant said, "... it kinda coached me through the activity ... and I thought about what it was she [the instructor] really wanted you to put in there." A similar attitude was adopted by another participant who tried to "parrot the examples" in the beginning of the semester. Towards the middle of the semester, as participants became more involved in their instructional project, most began to perceive scaffolding as a guide to help them achieve their own special needs. Participants began to speak about the advantages of having a "framework ... to help you pinpoint where you need to focus on" and "prompts that [thinking] and that definitely helps." In most cases, the change in participants' perception and use of scaffolding was an acknowledgement of the their individual needs and contexts. One participant admitted that she began to view the scaffolding in terms of its applicability to her project, and by extension, her life: "I'm beginning to say you know, how would this fit into my real life and what should I be concerned about getting from it and whatever."

Use and interpretation of scaffolding moved through three distinct phases—in the first, scaffolding was considered as directive instructions. In the second phase, scaffolding was used as a guide within participants' individual context. Scaffolding in the third phase was marked by interpretation and selection to suit individual needs. In the externally dictated mode, participants chose to implement the provided scaffolding literally and "answer the questions" or react in accordance to their perceptions of what the "instructor wanted." However, as participants became increasingly conscious of their individual contexts and goals, they began to perceive the scaffolding as a guide that allowed them to direct their thinking along appropriate and personally meaningful direction. Some participants used scaffolding in a customized manner from the very beginning and indicated that the customization was guided by relevance to their project goal. The other participants also indicated that they eventually changed their perception and use of scaffolding based on their individual project goals and needs. The findings of the study indicate that it is important to identify methods for alerting students to the function of scaffolding—that is, to assist them in realizing their individual goals. In the current study, goal realization was an individual process occurring at different times. The importance of continuously defining and refining the learning goal during the scaffolding interaction is a key component of Wertsch's (1984) explication of scaffolding processes. Goal clarification has been identified as a keystone for success in the assimilation and use of scaffolding by students of different ages and in a variety of settings (see for example, Rogoff & Wertsch, 1984; Saxe et al., 1984; Slotta & Linn, 2000).

Influences on Critical Thinking

Five elements seemed to influence the evolution of critical thinking: reflection, feedback, problem context, perception of self as learner, and prior knowledge. Reflection emerged as a very important influence in the development of critical thinking. One participant often mentioned the value of reflection in changing her thinking, specifically with regard to the assignments and the necessity of looking beyond "predefined notions of how to do" things. Other participants acknowledged the novel role and the value of reflection in their activities as exemplified in the quote by this participant: "Basically I would say that reflecting is a new element that's coming into play and looking at details is not something I've had to consciously do ...and it's not something that comes naturally to me." Authors such as Kuhn (1999) emphasize that fostering metacognitive and reflective skills is of utmost importance in promoting critical thinking. Brookfield (1986) identifies reflection as one of the most "useful" tasks in helping people think critically. Consequently, those participants who engaged in reflection often and who valued reflection as a tool to promote their thinking were most likely to engage in critical thinking.

Seeking and reacting to feedback was another influence on shaping participants' critical thinking in ID. Participants often mentioned their higher regard for seeking feedback, or as one participant said: "...maybe I'm just more comfortable hearing the feedback." Feedback was rated highly by participants as a means to gather different viewpoints and as a way of becoming more "open to just different ideas or different approaches." McPeck (McPeck, 1990)cites feedback or "rational disagreement" (p. 52) as one of the primary methods for stimulating the examination of ideas. McPeck also recommends that teachers who attempt to facilitate critical thinking in their students must learn to move their teaching from more "didactic" to "discursive" modes of presentation. This approach is consistent with the findings of the study, which indicate that feedback served to refine participants' understanding.

For many participants, the exigencies of their individual project context appeared to influence the development and evolution of critical thinking. The more authentic and unstructured the problem context, the more likely that

individuals engaged in critical thinking. The two participants who addressed authentic, ill-structured problems for their instructional project acknowledged the importance of the integral nature of the project in their lives, and thereby the additional meaning and reflection gained from the experience. Research and theory offers two perspectives on these differences. King, Wood and Mines' (1990) research suggests that reflective, critical thinking is most often triggered by ill-structured problems rather than "well-structured problems" (Churchman, 1971). Two other participants who engaged in relatively well-structured projects that involved very little ambiguity indicated fewer instances of critical thinking.

Participants' perceptions of themselves as learners, as well as their perceptions of their role as learners significantly influenced changes in their thinking. For example, one of the older participants indicated that she preferred to "mimic" the processes being presented and she consistently referred to her novice status as a hindrance for critical thinking. Another participant who characterized herself as a "creative" and "alternative" thinker, said that the analytical nature of thinking required within the course was not to her liking or style. These self-imposed conceptions of self as learner hindered critical thinking in the instance of these two participants. Brookfield (1986) suggests that adults' understanding of their learning styles, selves as learners, and patterns of learning is an important prerequisite for critical thinking. Learning styles are defined as "the characteristic and preferred way in which an adult engages in learning activities" (Knox, 1986, p. 20). Reflecting consciously on and understanding one's learning has two implications for critical thinking. First, an awareness of one's learning style allows an individual to select appropriate strategies for effective learning (Brookfield, 1986). In addition, such understanding can promote appropriate adaptation of learning styles to suit changed circumstances. For example, some of the other participants, while acknowledging distinct learning styles, mentioned that they tried to integrate their styles with the class requirements, and indicated higher levels of critical thinking.

The role of prior knowledge in shaping participants' critical thinking in ID was apparent in a number of instances. In the case of three participants, prior knowledge served as a basis from which to compare their current learning and experiences in the class. These three participants incorporated their prior knowledge and experiences into their understanding of ID almost from the very beginning. For one participant, prior knowledge served as a source of data for guiding and refining his thinking; for another, prior knowledge stimulated an acknowledgement of existing biases and the need to make a "conscious effort to displace yourself." In these instances, prior knowledge helped to activate a comparison of prior and current experiences and to stimulate additional thinking and reflection when an inconsistency was encountered. This finding is consistent with research on the role of prior knowledge in triggering additional reflection and the search for additional information (see for example, Baker, 1979; Pitts, 1994). In other instances, especially in the case of the youngest participant, prior knowledge conferred an authority to her thinking that impeded critical thinking and she said in explanation: "I know every aspect of it...." This attitude is consistent with research indicating that prior knowledge can give rise to counterproductive strategies such as assuming the validity of default knowledge (Phillips, 1992) or preserving information that supports one's beliefs (Klayman & Ha, 1987)

Relevance and Significance

This study has implications for different groups. First, practitioners and educators interested in developing critical thinking skills in their students might benefit from the results of this study in being able to identify how and why students choose to assimilate and use critical thinking skills when adequately supported by scaffolding. Second, using the strategies recommended in this study as a launching point, designers and developers of online or technology-mediated instruction might adapt and introduce more effective strategies for implementing scaffolding for critical thinking in such environments. Specifically, this study provides a starting point for those interested in designing and implementing scaffolding for critical thinking related to Instructional Design, and encouraging further research and design based on the results of this study.

Apart from practical implications, this study contributes some interesting theoretical perspectives on scaffolding and critical thinking. In literature on scaffolding, attention has been focused in two main areas: (1) identifying characteristics of an expert "scaffold" (see for example, Lepper et al., 1997; Saxe et al., 1984; Wood et al., 1976), and (2) identifying outcomes of the scaffolding interaction between expert and novice (see for example, Hogan & Pressley, 1997; Kao & Lehman, 1997; Salomon et al., 1989; Slotta & Linn, 2000). This study contributes to a missing perspective—the role of student characteristics in assimilating and using scaffolding. By identifying a few of the cognitive characteristics and beliefs that affect student use of scaffolding, this study offers a starting point for other researchers who are interested in further exploring the interaction of student characteristics and scaffolding.

A second area of theoretical contribution is offered in this study's description of the influences on development of critical thinking. Although students may be eminently capable of thinking critically, a variety of influences preclude the development and demonstration of critical thinking skills. The documentation and description offered in this study also offer a starting point for exploring and deriving theoretical frameworks that define the impact of student and context characteristics on the development of critical thinking.

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